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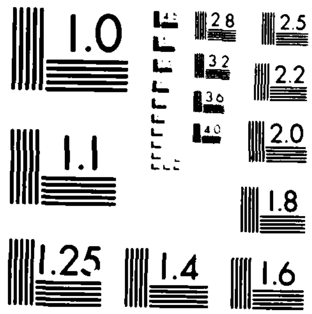

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Effects of cognitive complexity (multidimensionality vs. unidimensionality and of Type A behavioral style (a coronary prone behavior) on four measures of task performance in a visual-motor task were investigated. Subjects were exposed to four load levels which produced task settings ranging from relatively easy to extremely difficult. It was found that increasing load increases both risk taking and errors, and decreases strategic planning and overall task performance. More multidimensional (complex) persons

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engaged in considerably more strategic planning and made fewer errors than their more unidimensional (less complex) counterparts. Differences between these two groups were particilarly evident at higher (more stressing) load levels. Type A Coronary Prone Behavior had no effects on performance whatsoever. Implications of these findings for the Type A personality and for tasks requiring some degree of planning or strategy are discussed.

Cognitive Complexity, Type A Behavioral Style and Load as Predictors of Visual-Motor Task Performance

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Previous research (e.g., Streufert, 1970; Streufert and Schroder, 1965; Streufert and Streufert, 1982; Stager, 1970; Suedfeld, 1978) has supported predictions of complexity theory concerned with the effects of load stressors on a number of performance variables. Deprivation or underload appears to result in depressed performance and high salience of the available information (including responses to irrelevant but available information, c.f. S.C. Streufert, 1973). Overload inhibits complex performance, such as differentiation and integration (e.g., strategic planning) in complex decision making tasks, but may increase the frequency of simpler behaviors (e.g., respondent decision making as reported by Streufert, Driver and Haun, 1967). Intermediate (often called optimal) load levels appear to produce maximal levels of differentiation and integration in complex decision making tasks (including strategic planning activities) and tend to result in moderate levels of simpler (e.g., respondent) behaviors.

It is not surprising that most of the research relevant to complexity theory predictions has been accomplished in relatively complex task settings. Many simple tasks neither require nor permit the "differentiative" and "integrative" cognitive information processing that produce effects (e.g., strategic and planning behaviors) that are of interest to the theory. Nonetheless, there are a good number of "simpler" tasks that do. Take, for example, the work of the radar operator or air-traffic controller. He or she performs precise tracking tasks, yet often translates these perceptual inputs into limited alternative decision outcomes. Future consequences for current decisions may have to be considered. Such task performance relates to the decision alternatives under uncertainty discussed by Wohl (1981). In addition, tracking tasks of that nature may include various levels of stressors (e.g., information load, as discussed by complexity theorists).

Recently, Streufert and Streufert (1978) have tested some complexity theory predictions in a relevant visual-motor task setting. That research measured the effects of load (from optimal to superoptimal levels) on both simple respondent and strategic behaviors. It was found that load effects in the visual-motor task appeared to be quite similar to previously obtained load effects on performance in more complex decision making tasks: increases in load levels toward superoptimal load resulted in decreased utilization of strategy, increasing tendency to make errors and, consequently, in decreased quality of task performance. The present research was designed to confirm and extend those findings by including two stylistic variables which are likely to be relevant to task performance predictions: (1) cognitive complexity and (2) Type A behavior. Both variables will be discussed in the sections below.

Cognitive Complexity

Complexity theory predictions are not restricted to load (and other environmental stressor) variables alone. The theory (Streufert and Streufert, 1978) also predicts complex task performance based on the actor's cognitive complexity, i.e., his or her tendency to perceive and/or perform in a multidimensional (as opposed to unidimensional) fashion. Multidimensionality is minimally differentiation (c.f., Bieri, 1961) of dimensions and may also include various levels of integration (c.f., Schroder, Driver and Streufert, 1967) of differentiated dimensions. As suggested by Scott and associates (e.g., Scott, 1962, 1963, 1969, 1974), cognitive complexity may be specific to particular cognitive domains. Recent interactive complexity theorists (e.g., Streufert and Streufert, 1978) have suggested that differentiation and integration in task performance (e.g., strategic behavior) can be represented as a family of inverted U-shaped curves producing their greatest discrepancy between more unidimensional persons (low performers) and multidimensional persons (high performers) at a single "optimal" intermediate point on the load variable. Considerable research has determined that optimal load (for complex tasks) is obtained when one item of information is received by decision makers per (on the average) three minutes. Considerable research in various cultures utilizing a number of diverse tasks has substantiated these findings.

The predictions for differences in performance between more versus less complex individuals should hold as long as utiliztion of strategy (strategic planning over time) is a necessary part of the task at hand. As a result, the theory may equally well apply to simpler tasks where strategy is utilized, such as air traffic control and similar efforts. The visual-motor task developed by Streufert and Streufert (1982) was

specifically designed to represent these kinds of tasks. The present research again utilizes the same task environment. The research was designed to test whether persons who are cognitively complex (multi-dimensional) would outperform their less complex (more unidimensional) counterparts.*

Type A Behavior

Rosenman and Friedman (Rosenman, 1978) developed a series of descriptions and a measurement instrument to capture coronary prone behavior. The "Type A" individual (as distinguished from his "Type B" counterpart) tends to display time urgency, hostility, aggression, and a competitive drive. Type A behavior is apparently encouraged by contemporary cultures and is believed by many to be the basis of their success. Considerable research has determined that the Type A individual overreacts to environmental inputs, both behaviorally and physiologically [see, for example, the extensive research program of Dembroski (e.g., Dembroski, MacDougall, and Shields, 1977; Dembroski, MacDougall, Shields, Petitto, and Lushene, 1978) and others] resulting in increased morbidity and mortality. Programs designed to diminish Type A responsivity in individuals have often encountered resistance from Type A's who believe that their style is necessary to maintain the success they have experienced at their respective tasks. Research by Streufert, Streufert and Gorson (1981) has demonstrated that <u>induced</u> (but not necessarily stylistic) time urgency does not aid in complex task performance; as a matter of fact, strategic actions may suffer greatly when time urgency reaches

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*It should be remembered that cognitive complexity, as demonstrated in considerable previous research, is not correlated with intelligence or other abilities or with personality measures.

high levels. Whether or not the strategic or planning behavior of actual Type A persons is more or less effective or is equivalent to such behavior in Type B persons remains yet to be investigated. The present research was in part designed to approach that question. The current research effort is based on a two by two by four design. More multidimensional Type A individuals, more multidimensional Type B individuals, more unidimensional Type A individuals and more unidimensional Type B individuals were exposed to four load levels in the visual-motor task developed by Streufert and Streufert (1982). The following performance outcomes are measured: (1) overall performance, (2) risk taking, (3) errors, and (4) utilization of strategy.

METHOD

Forty-two employed adult males* participated as individuals in a series of interviews and tasks. Subjects remained in the laboratory for approximately four to five hours each. The research included a complexity interview, a Type A interview and a visual-motor task (discussed below). Upon arrival at the laboratory each subject was briefed about the forthcoming events and the subject's signature on a consent form was obtained. The subject was then taken to the laboratory rooms where data were collected (see below).

Complexity Interview

The subject was comfortably seated and handed a set of cards by an experimenter. Each card contained the stem of a sentence (e.g., when someone competes with me . . .). The subject was asked to complete the sentence and to continue talking about the topic. Topics were specific to various

*Because of greater availability only male subjects participated in this research. Generalization of the obtained data to females should be made only with extreme caution.

cognitive domains listed by complexity theorists. After the subject finished the initial responses to any one card, the experimenter asked several non-leading questions, designed to encourage the subject to (a) continue responses to the topic at hand, and (b) reveal the cognitive dimensionality on which the responses were based. When the subject's repertoire of responses to a topic was exhausted, he was asked to continue with the following card. A total of twelve cards were presented. The procedure is designed to assess level of cognitive complexity and represents an interview version of the sentence completion test (SCT, in some versions also called paragraph completion test) developed by Schroder and Streufert (1963) and Schroder, Driver and Streufert (1967). Reliability and validity of the test is excellent (c.f., Streufert and Streufert, 1978).

Type A Interview

The Structured Interview (S.I.), designed by Rosenman and Friedman to assess Type A behavior (c.f., Roseaman, 1978), was administered by a different experimenter since it was necessary to avoid the subject beginning the interview with any previously established impressions of the interviewer. The interview represents a standardized social challenge situation considered by many to represent considerable social stress. The experimenter interviewing the subjects was trained by Rosenman. Responses to both interviews were videotaped. Both interviews were scored by at least two experimenters, each with extensive training in these methods. Scorers of the Type A interview were trained by Rosenman. Scorers of the complexity interview were trained by Streufert. Disagreements greater than one point discrepancies on the respective scales did not occur.

Visual-Motor Task

A visual-motor task, previously developed by Streufert and Streufert (1982), was utilized in this research. The task uses the format of a video game, not unlike the familiar Pac-Man. In contrast to other video games, however, the speed of movement and the number of antagonists (stressing load) can be precisely varied in several steps. The game utilizes a series of concentric passageways that are filled with a number of squares which the subject is to "scoop up" with a horseshoe-shaped object that he is able to move by operating a handle on a small box placed on the subject's desk. The matrix of passageways is presented in Figure 1. The subject begins with a score of five points. Scooping up one square adds five points to the score. Moving through one unit of empty space between the squares subtracts one point from the score. In other words, a continuous movement through spaces filled with squares would add 5-1=4 points for each square collected. Moving through spaces where no squares are present would subtract one point for each empty space, including those spaces previously occupied by squares. In other words, to obtain as high a score as possible, it is useful to avoid moving through blank spaces, i.e., to move so that as many squares as possible can be picked up in one more or less continuous series of moves. Movement is possible only through passageways. Movement across solid lines is not possible.

In addition to the squares, from one to eight dots (differently colored) can appear in the matrix shown in Figure 1. The dots move randomly along the passageways of the matrix, reversing their direction (again randomly) from time to time. The dots are to be avoided: colliding with them is

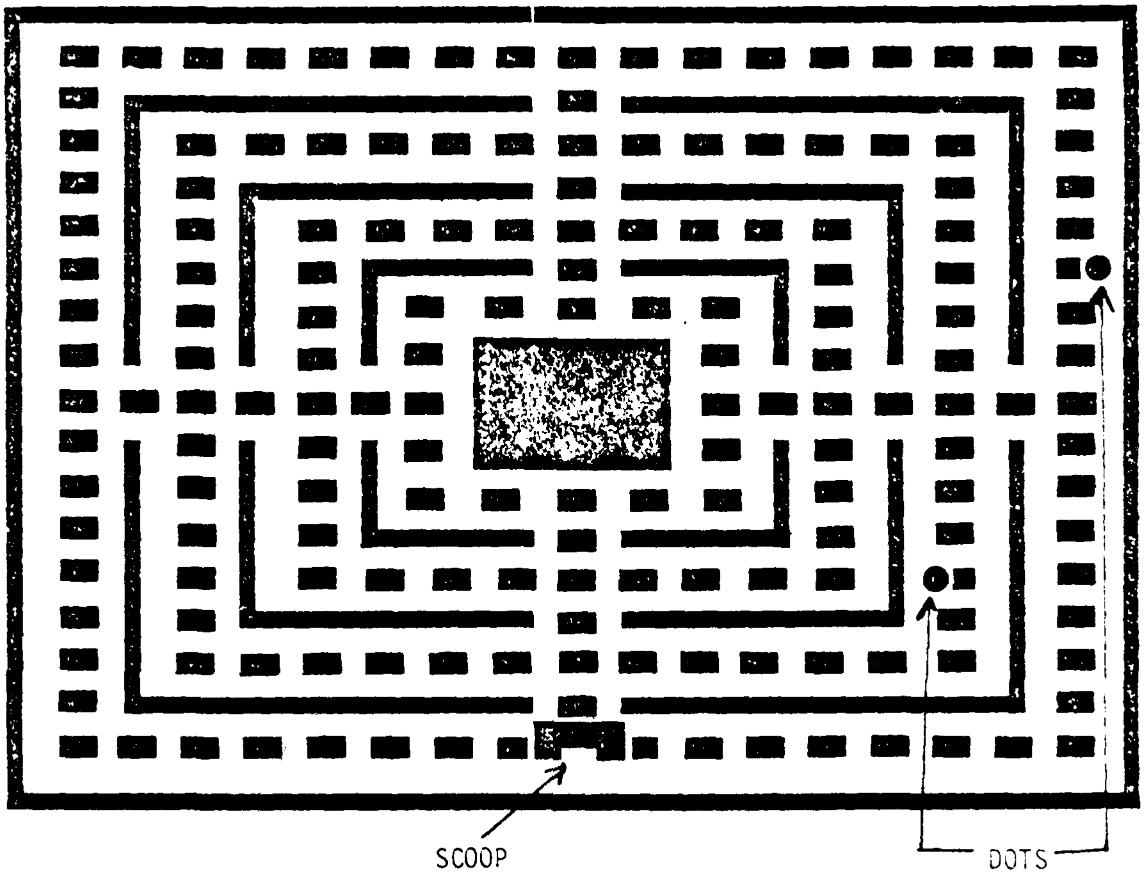

FIG. 1. Task matrix.

considered an error, costing the subject 100 points for each collision. A collision removes the dot to a different random position in the matrix so that a second collision due to the same error is highly unlikely.

The computer program permits the experimenter to systematically vary a number of characteristics which apply during any one task period. The characteristics which can be modified are: (1) the speed of movement for both the subject's scoop and the dots which the subject is to avoid. Speed can be increased or decreased in four equal interval steps; (2) the number of dots on the screen (varying from one to ten); and (3) a constant score (displayed on the screen throughout any task period). The score reflects an experimenter-selected value indicating either the supposed average score obtained by other subjects on their first try or (optionally) the highest score obtained by any subject. In addition, the experimenter is free to select the number of task periods which are to be employed. Each period lasts until the subject has successfully scooped up all the squares from the matrix on the video screen. The subject's current score is continuously and prominently displayed at the bottom of the screen. As stated, the subject's current score starts at +5 and increases as more and more squares are captured. It decreases with collisions with dots and movement through blank spaces. The score may become a negative value if the subject moves through blank spaces 2.5 times more often than through spaces still occupied by squares or if he repeatedly loses blocks of 100 points by collisions with dots.

Instructions to Subjects

Subjects were instructed in detail via video tape about the operation of the task. They were reminded to avoid collisions with white dots.

They were also told about the loss of points created by moving through blank spaces. They were further asked to try to do as well as possible, to avoid letting scores drop below zero, and to try hard again during the next task period if they are not as successful as they might wish during any previous period. While the subjects were reminded of the consequences of failing to use strategy, they were not told what strategy should be used to obtain maximal scores. Instructions were moderately challenging, and can be considered somewhat below the challenge and competition level induced by Dembroski, MacDougall, Shields, Petitto and Lushene (1978). The level of challenge and competition selected for these instructions was based on a representation of work environments rather than of experimental environments. Subjects were told to expect different speed levels and different numbers of dots to be avoided from one game period to another. The actual number of periods that would be played was not specified in advance.

Load Manipulation

Subjects were initially given a practice try to familiarize themselves with the task and to eliminate or decrease the potential effects of previous experiences with video games* For the practice task, speed was held at level 1 (low). Only one dot was presented in the matrix. After completing this task period (and after all other subsequent periods), subjects responded to a number of seven-point scales (manipulation checks). After completing the scales, the subject was asked whether he was ready to

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*Previous experience with video games, in general, and with Pac Man specifically, did not affect performance.

try the task again. All subjects responded positively in all cases.

All subjects participated in four task periods following the practice period. The number of dots, representing the load manipulation,* was systematically varied for these four periods. Either 2, 4, 6 or 8 dots were placed into the matrix. Order of presentation was based on random sequences checked via a counterbalancing procedure to assure that specific load levels would not occur inordinately often at any sequence position. Speed for all four task periods was held at level 2 (moderate). Subjects were not aware of what their next load level would be until the matrix with the relevant number of dots appeared on their screen at the beginning of the task period.

A read-out at the bottom of the video-screen informed subjects during the first (practice) period that the average score obtained by other subjects during their first try had been 435. That score level was rather easy to achieve and was surpassed by all but two of the subjects in this research. For the following four task periods, the subscript on the screen indicated that the highest score obtained by any subject so far had been 898. None of the subjects achieved or surpassed that score.

The performance of all subjects in response to tasks at all load levels was video-taped for later analysis. Data were based on performance scores for the four periods following the practice period. Order of presentation of this task and the interviews was varied to eliminate potential sequence effects.

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*In complex tasks (e.g., Streufert, 1970) load was defined as the number of information (stressor) items per unit time. Load in the present task has a quite similar meaning. While time is held constant, the subject had to attend to the number of antagonistic dots in the matrix, representing levels of loading stressor conditions.

Scoring the Task Performance

1. Strategy. Any movement of the scoop (as controlled by a subject) which clearly facilitated collecting squares that at a later point could only have been reached by moving through blank spaces was assigned a score of +1. For example, let us assume that a subject had previously collected all but three squares in one of the passages of the matrix (and had to leave the last three standing because he was "chased" by one of the dots). If he later found himself (while collecting other squares) at the nearest point to those three dots, he would receive one strategy point for collecting those three squares at that time rather than waiting until a later time when he would be further removed from those squares across blank space.

Any movement which clearly left squares in the passageway or next to the passageway of a subject's scoop (with no interference by a dot), at a point where they would have to be picked up later at a cost of moving through blank spaces, was assigned a score of -1. For example, if a subject initially erased all squares in the outside passage and then proceeded to the next set of passages, counting from the outside, without picking up the three (one was removed by moving from the outermost to the next passage set) squares on the cross passages, he would have to return later through blank areas to scoop up those squares. Such a set of moves would be unstrategic and would result (if all three squares were left standing) in a score of -3. Scores were summed for each of the task periods.

2. Error scores. Each collision with a dot was scored as an error. Dots could be avoided by: (1) selecting passageways for activity where no or very few dots were currently present, and (2) reversing direction far enough in advance of an approaching dot to safely turn into another passageway at the next intersection. Reversing through blank spaces was much less

costly (in terms of subtracted scores) than colliding with a dot. Avoidance of errors was considered successful respondent (more simple) behavior while obtaining positive and avoiding negative strategy scores was considered a form of more complex performance, somewhat akin to the differentiation/integration measures obtained in earlier research with complex decision making tasks.

3. Risk taking. Risk taking scores reflected the distance between the subject's scoop and any oncoming dot at the time the subject reversed direction. Distance values were obtained in movement units (see the description of the task, above). A measure of one (highest risk level) would mean that a collision did occur or would have occurred (in the absence of reversing direction) during the next motion instant of the task. In other words, a low score implied greater risk taking. Reversal of direction at a distance of five movement units or greater was assigned a score of five, suggesting very low risk levels where collisions could not occur.* Scores of two through four reflected precisely that number of movement units between scoop and dot at the point when a subject reversed the direction of his scoop.

Risky behavior in approaching an oncoming dot as far as possible (without reversing direction) may be explained by (1) the hope that the dot would reverse direction (which it did occasionally on a random frequency basis),

*Reversal of direction at risk level 1 (one movement unit apart) necessarily resulted in a collision if the dot pursued the subject's scoop to the next turn in the matrix. With a reversal at score 2, a collision occurred about 50% of the time. Reversals at score 3 and above made a subsequent collision less and less likely. Collisions at risk levels 5 or above did not occur, unless the subject caused those collisions by subsequent inappropriate actions.

and (2) the desire to avoid minor losses associated with movement through blank spaces where squares had already been collected. In other words, incentives for approaching an oncoming dot as far as possible before reversing direction did exist.

4. Game score. The current score (and changes in that score) during any point in the task was continuously displayed on the video screen beneath the task matrix. The computer calculated this score by providing the sum of five (initial free) points plus five points each for each square collected minus one point for each empty square traversed and minus 100 points for each collision. The final game score appeared in a prominent position (announced by fanfare type sound) after all squares had been collected. In other words, each subject was made clearly aware of his level of accomplishment at the end of each of the game periods.

Final scores reflected both the degree of strategic behavior and the avoidance of errors, i.e., moderate levels of riskiness resulting in relatively few collisions with oncoming dots. Since poor strategy would necessarily prolong the task (the subject would have to return to previously uncollected squares through considerable distances in which dots would be potentially present), error scores would be increased by inappropriate respondent behavior and to some degree by lack of strategic behavior. Consequently, a high error score would overly affect the final game scores more significantly than low scores for strategic behavior.*

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*A greater impact of a considerable number of errors upon the final score was chosen, since errors in simple respondent decision making would likely have more immediate impact on task performance. Strategic performance without adequate respondent performance would not likely be very useful in most tasks. In the present task, final game scores tended to correlate (for all groups throughout all load conditions) at the level of -.85 to -.90 with errors and at levels of approximately +.50 with strategy scores.

RESULTS AND DISCUSSIONS

Of the forty-two subjects, all but one could be identified in terms of the Type A vs. Type B distinction and in terms of the multidimensional (i.e., cognitively complex) vs. unidimensional (i.e., less complex) categorization of complexity theory. Persons with complexity scores of three (differentiator) through seven (high level integrator) were placed into the "multidimensional" category. Two of the subjects in this group scored in the differentiation range between 3 and 3.5, the remaining subjects scored within the integration range. Persons scoring below 3.0 were assigned the unidimensional category. Scores were based on the "Two-High" method, i.e., the mean score of the two highest (most complex) responses to cognitive domain specific sentence stems was utilized to distinguish between "unidimensional" responders and "multidimensional" responders. In other words, persons classified as multidimensional for this research may not have been differentiators and integrators across all cognitive domains.

Type A vs. Type B scores were assigned via the method developed by Rosenman and Friedman. As stated above, scorers were trained by Rosenman. Type X (neither A nor B) assignments were not made. One subject could not be scored and was dropped from further analysis.

The remaning forty-one subjects were placed in a 2 x 2 matrix (multidimensional vs. unidimensional and Type A vs. Type B) as follows: 12 subjects were considered Type A multidimensional, 12 subjects were considered Type A unidimensional, 8 subjects were considered Type B multidimensional and the remaining 9 subjects were considered Type B unidimensional. All subjects' scores for all four load conditions were entered into the data analysis.

Four separate 2 x 2 x 4 Analysis of Variance procedures (for Game Score, Risk Taking, Errors and Strategy) were utilized to analyze the obtained data. Each of the analyses is discussed below.

Risk Taking

The analysis for risk taking scores produced a significant main effect for load levels ($F = 8.168$, 3/111 df, $p < .001$). As shown in Figure 2, risk taking increased with load levels. Similar data have been obtained previously by Streufert, Streufert and Denson (1982). As in that research, increases in risk taking with load were gradual and stepwise.

Main effects for Type A or for Cognitive Complexity (dimensionality) were not obtained. An interaction effect of load by complexity approached, but did not reach, conventional significance levels ($p = .126$) and will not be considered. Other main effects and interaction effects remained far from significant.

Errors

Error scores (number of collisions with dots) tended to correlate with risk at levels varying from -.15 to -.7 (remember that low risk scores imply greater riskiness, i.e., greater probability of high error scores due to collisions). The analysis for error scores resulted in a significant main effect for load ($F = 81.120$, 3/111 df, $p < .001$). A main effect for complexity again did not reach significance ($p = .125$). However, a significant load by complexity interaction was obtained ($F = 4.794$, 3/111 df, $p = .003$). As shown in Figure 3, multidimensional subjects, as compared with unidimensional subjects, made (insignificantly) more errors when load levels were very low and made significantly fewer errors at high (level

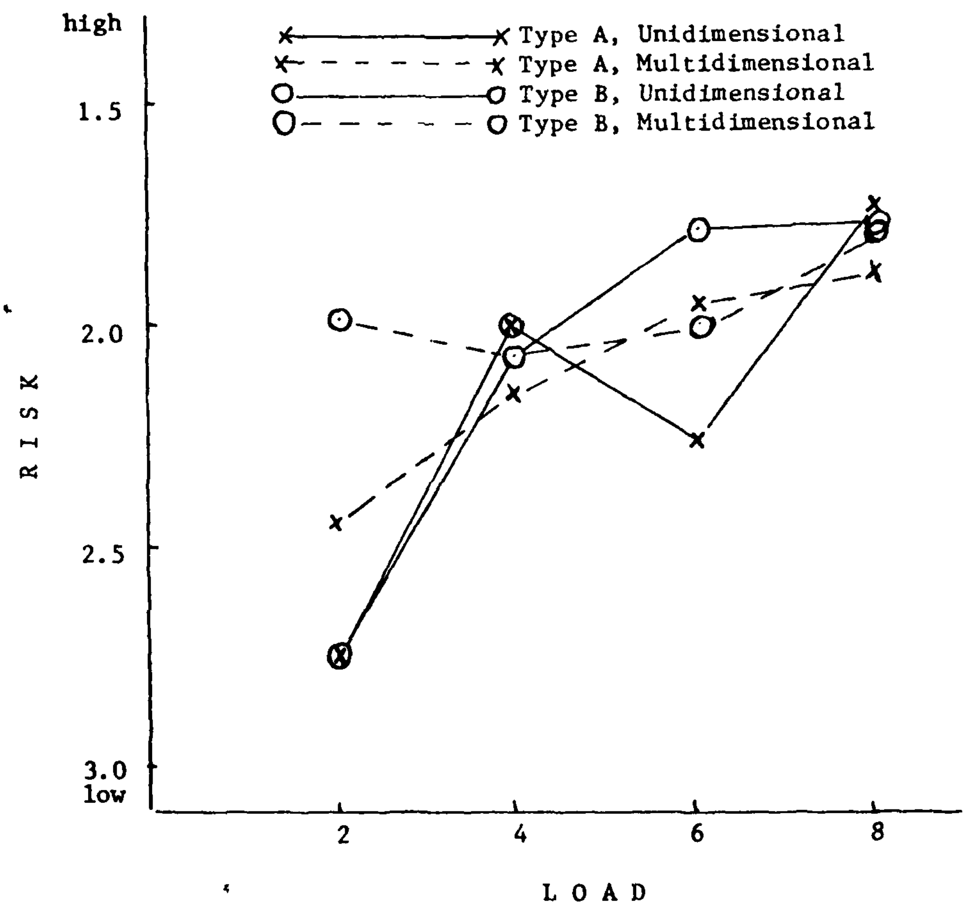

FIG. 2. Effects of load on risk taking.

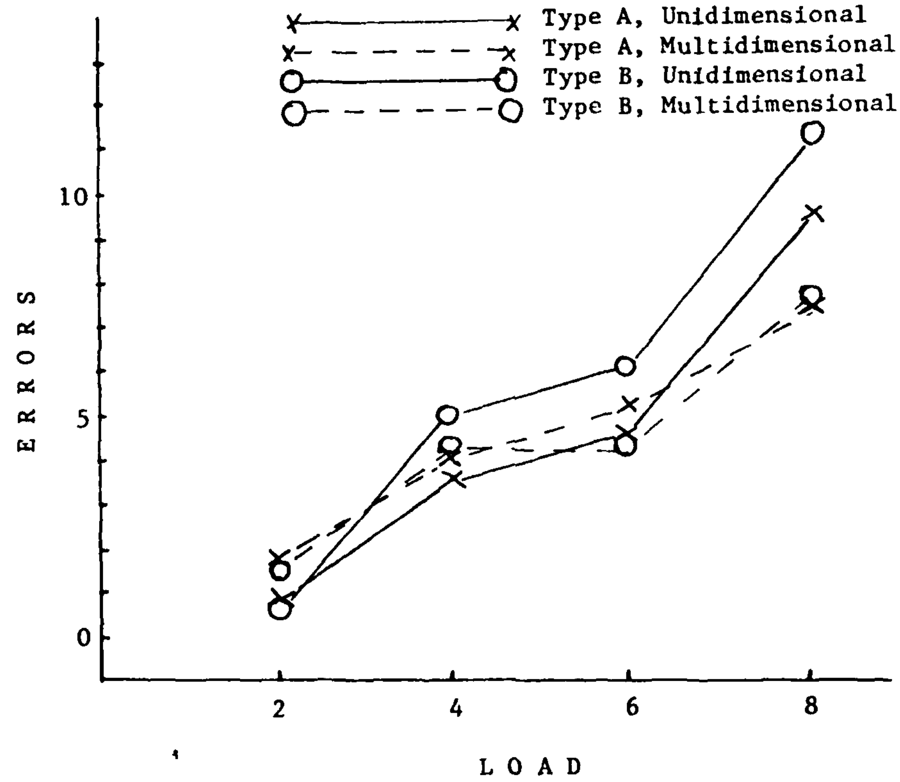

FIG. 3. Effects of load on errors.

eight) load levels. Main effects or interaction effects involving the Type A characteristic did not reach or approach significance.

Strategy

The analysis for strategy scores produced significant main effects for cognitive complexity ($F = 58.587$, 1/37 df, $p < .001$) and for load ($F = 15.944$, 3/111 df, $p < .001$). Cognitive complex (multidimensional) persons engaged in considerably more strategic behavior than less complex (more unidimensional) persons. Load decreased strategic behavior (see Figure 4). Interaction effects were not significant. The Type A main effect and all interaction effects which include Type A did not reach or approach significance.

Game Score

As discussed above, the game score is for the most part an outcome of risk-produced errors and of strategy. The analysis for game score produced a main effect for complexity ($F = 6.560$, 1/37 df, $p = .014$) and for load ($F = 67.636$, 3/111 df, $p < .001$). The complexity by load interaction effect ($F = 2.873$, 3/111 df) reached significance at the $p = .038$ level. Game scores decreased with load and were higher for cognitively complex persons. The differences between complex (multidimensional) and less complex (more unidimensional) persons were particularly evident at the higher load levels (see Figure 5). Again, the Type A main effect and all interactions involving Type A did not reach or approach significance.

Data Interpretation

The most striking finding of the present research is the complete absence of any effect of Type A vs. Type B stylistics on any measures obtained. Certainly Type A persons were given sufficient opportunities to express

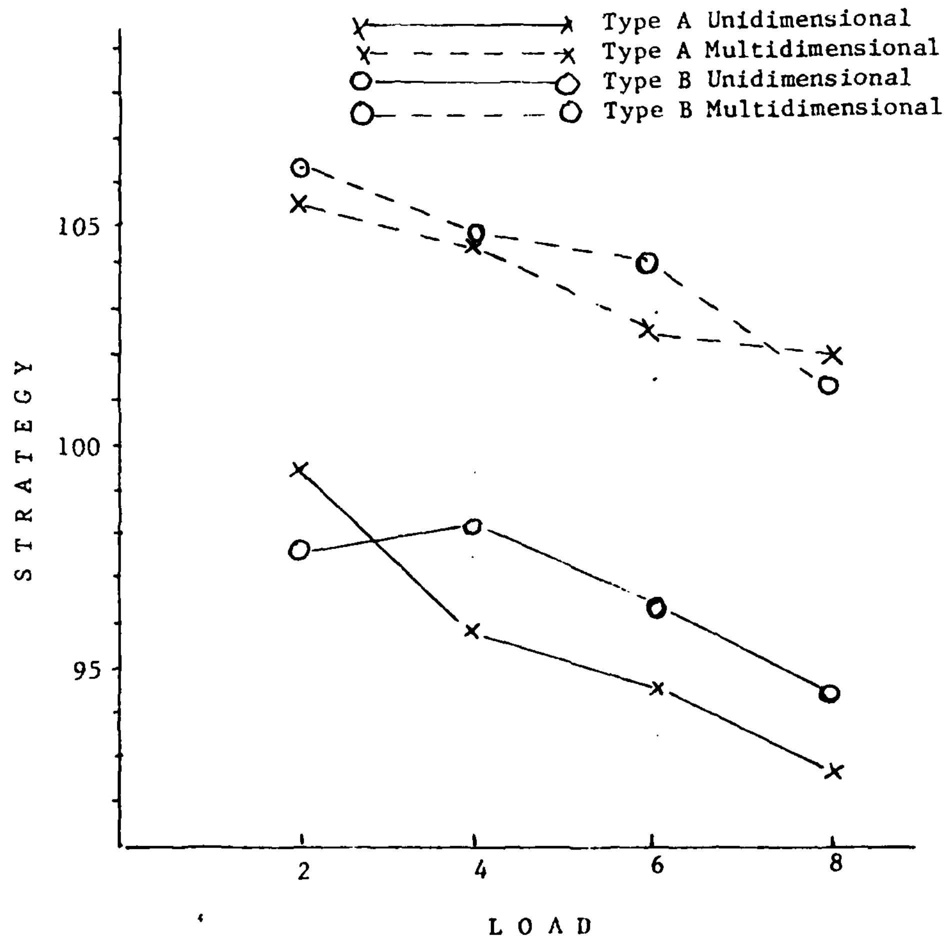

FIG. 4. Effects of load on strategy.

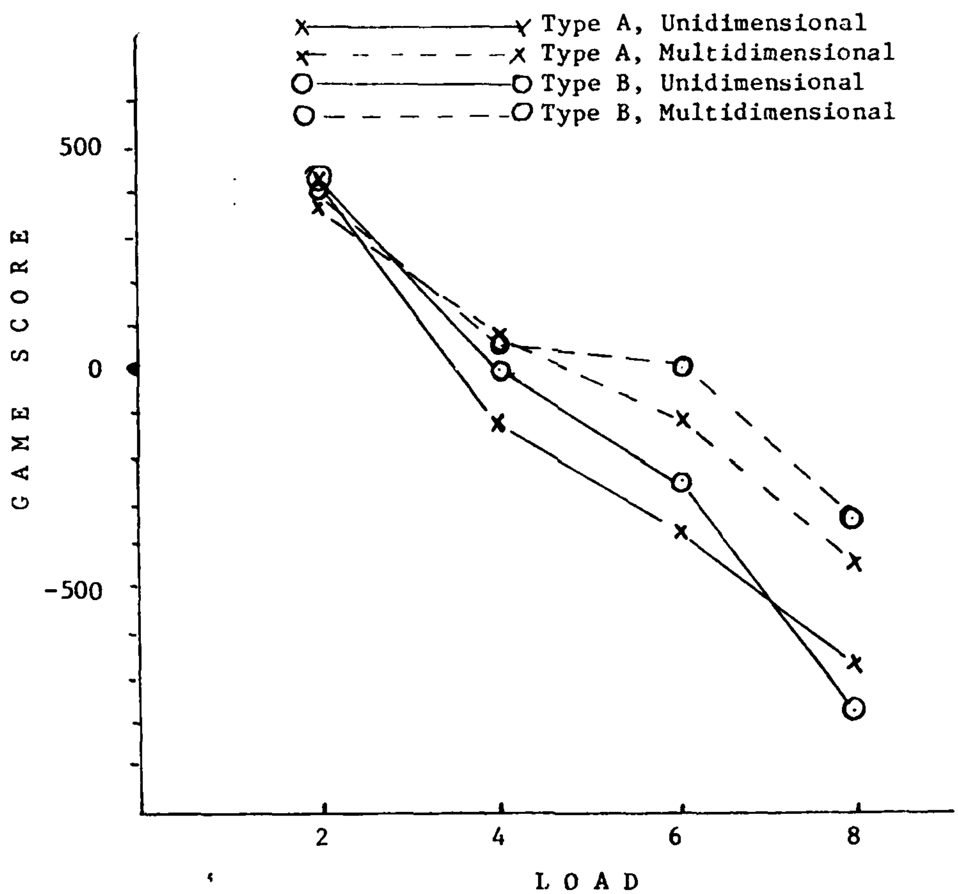

FIG. 5. Effects of load on game score.

their behavioral style. Challenge and the threat produced by having to cope with the antagonist dots in the matrix were certainly provided. As Streufert, Streufert and Denson (1982) have shown, participation in this task, particularly at high load levels, does result in the elevated physiological responsivity (heart rate and blood pressure) in subjects identified as Type A that is generally associated with Type A behavior. However, that Type A hyperreactivity was not reflected in task performance. This finding strongly argues against a view which is often expressed by persons who are identified as Type A; many of them believe that their style is essential to satisfactory task performance. The present data, in part, corroborate previous findings of Streufert, Streufert and Gorson (1981) who demonstrated that induced time urgency is not helpful and may be detrimental in the performance of complex tasks. Nonetheless, the present results, even in association with the data of Streufert et al (1981), are not yet sufficiently conclusive and need to be re-tested in other (simpler as well as more complex) task settings.

As expected by complexity theorists, cognitive complexity (multidimensionality) did result in greater utilization of strategy (i.e., planning) and in better task performance for this experimental task. Also, as expected, the degree of strategy utilization and consequent levels of task performance did decrease with increasing load. The differences between more complex (multidimensional) and less complex (more unidimensional) persons were particularly evident at higher load (greater stress) levels. While data of this kind have been previously obtained in more complex (e.g., decision making) tasks which include considerable uncertainty, they had not been so far demonstrated for the kind of task employed in the present research.

One may then conclude that the predictions of complexity theory extend to simpler, here visual-motor, tasks as well, as long as successful performance of such tasks requires at least some strategic or planning activities. It remains in question whether more cognitively complex individuals would outperform their less complex counterparts in extremely simple tasks where strategy and/or planning is not involved (even though the present experiment does suggest somewhat more successful avoidance of erros, i.e., more effective respondent behavior by cognitively complex subjects). This question remains to be tested in future research.

For purposes of comparison with previous research which has focused on complex tasks where load was varied from deprivation to overload conditions, it should be emphasized that the present visual-motor task was not designed to include a low load (deprivation) condition. In other words, only decreases in performance and its components (increasing risk, increasing errors, decreasing strategy) could be expected with increases of load toward superoptimal stressor levels.

Certainly more research is needed before implications of the present data for real-world tasks (e.g., radar tracking, air traffic control, etc.) can be derived with considerable certainty. Nonetheless, the data appears to suggest that superoptimal increases in load are likely to diminish strategic behavior (e.g., planning) and may generate greater risk taking and more errors in visual-motor efforts, possibly including radar tracking and/or air traffic control tasks. Further, the data suggest that cognitive complexity (multidimensionality) may be quite useful to obtain improved levels of performance and that Type A coronary prone behavior is not helpful in

improving performance. Future attempts to replicate the results of this research in similar and dissimilar tasks would be quite useful to substantiate the present findings and their potential implications for real-world task performance applications.

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